first grow inwards into the body-cavity of the planula. It is only just before the escape of the actinuloid from its capsule that they evaginate themselves and become external.

22. After enjoying for one or two days its free existence, during which it moves about by the aid of its long arms, the embryo fixes itself by its proximal end, the long arms gradually disappear, the short permanent tentacles increase in number, and the essential form of the adult is soon acquired.

XXXIX.—*Development of the Marine Sponges from the earliest Recognizable Appearance of the Ovum to the Perfected Individual.* By H. J. Carter, F.R.S. &c.

[Plates XX., XXI., & XXII.]

It is now twenty-five years since my figure of the Freshwater Sponges, viz. *Spongilla*, as it grows out of the so-called "seed-like body," was described and published ('Annals,' 1849, Sept., vol. iv. pl. iv. fig. 2), and seventeen years since the observations and illustrations in my paper "On the Ultimate Structure of *Spongilla*" were obtained by following this development ('Annals,' July 1857, vol. xx. p. 21, pl. i.). My military duties at Bombay then compelled me to remain much at home, while in the tanks of the garden about the house where I lived *Spongilla* grew abundantly; so that, although I resided for many years at Bombay, and thus on the borders of the sea, I could only make use of the opportunities which the freshwater tanks of the island afforded.

Time has passed, and I have retired to my native place (Budleigh-Salterton, south coast of Devon), still on the "borders of the sea," but now in Great Britain. The duties of official occupation are over, and I have yet a little time left to study now the physiology of the marine sponges.

This may explain to those who, like Häckel ('Die Kalkschwämme,' vol. i. p. 28), express wonder that I should have exclusively studied the freshwater sponges while at Bombay, where there is, too, such a rich sponge-fauna on the "coasts of the Indian Oceans" for this purpose. Had I been a German professor, the matter might have been different, and I might have obtained indulgences in the way of "leave" for studying the marine sponges, which the military authorities at Bombay, if they had been appealed to on this behalf, would have laughed at.

But to show that while on "the coasts of the Indian Oceans" I did not entirely neglect the marine sponges, it might be stated that, while attached to the survey of the south-east coast of Arabia in 1844–46, I made a collection of all the marine sponges that I could find there, and sent them home just afterwards to Dr. Bowerbank, who received and thanked me for them; but here *this* matter ended, and would have ever done so had I not felt the loss of a report on them, and especially the specimens themselves, in arranging the coltion of the British Museum, where I should have been most glad of representations of this part of the world.

If another survey is made of that unfrequented shore, and another collection of sponges is gathered from it, I trust that the latter may not be attended by such misfortune!

Two or three of these sponges, however, whose figures I had drawn and whose duplicates I had retained, I have been able to describe and illustrate ('Annals,' 1869); and since then my kind friend Dr. J. E. Gray has, by his desire that I should go on with the study of the marine sponges generally, and his unceasing exertions to place within my reach every thing in his power to facilitate this inquiry, ending with opportunities for examining and arranging the whole collection in the British Museum, caused me to obtain such a practical knowledge of the subject, so far as specimens of sponges, both dry and in spirit are concerned, that I felt it absolutely necessary to preface a *résumé* of all this by that physiological study of the development of the living marine ones which my present residence on the sea-shore enables me to follow.

For this purpose I have for some time past been desirous of finding out specimens of these sponges in an oviparous state; and although this may be often done in any part of the year while the ovum is very young, or only just distinguishable, yet it has not been until lately that I have found specimens of these sponges in which the ovum has become much enlarged and developed into the embryonal state—that is, ready for delivery.

Of the calcareous sponges it was stated ('Annals,' 1874, vol. xiv. pp. 98 & 107) that *Grantia compressa* &c. went through this oviparous development in the months of March, April, and May, and that at this time none of the siliceous sponges that I could find appeared to be in a like condition.

Since then, however, viz. on the 30th July and 29th August respectively, I have found several siliceous sponges, together with one of the non-spiculous ones belonging to Schmidt's Halisarcinæ, viz. *Halisarca lobularis*, Sdt., in which the ovum has presented all the stages of development, from its earliest appearance to the full-formed embryo; that is to say, on the former date was found *Halisarca lobularis*, *Halichondria* *simulans*, Johnston, *Esperia ægagropila*, var., Cart., with still a few specimens of *Grantia compressa* in this condition, and on the 29th of August *Halichondria sanguinea*, Johnst., *H. incrustans*, J., *H. panicea*, J., and *H. plumosa*, J., together with many more specimens of the sponges first mentioned; so that it would appear that the active reproductive state of the siliceous sponges, viz. that in which they are about to throw off their ova in the state of embryos, should be chiefly sought for in the months of July and August, probably including September,—a point which it appears to me desirable to establish for the advantage of others wishing to follow this pursuit, while before entering upon the development of the ovum and embryo into the perfect sponge it also seems advisable briefly to premise, for the same purpose, what experience has taught me in this respect, which is as follows, viz.:—that sponges for the most part grow upon the *under* surfaces of rocks; that to obtain the greatest variety it is necessary to be present at the "springs," as the tide falls lowest then, provided the wind be blowing "off" instead of "on" shore; that we should work down with the last hour's fall of the tide; and that this work should chiefly consist in breaking off with a heavy crow-bar such ledges of the rocks as bear sponges of different kinds in large quantities, and carrying them up to a pool far above low-water mark, where they can be examined deliberately after the tide begins to rise, since both the fall and the rise of the tide take place so rapidly that there is no time for examining the specimens at the moment. Particular portions may be knocked off with a heavy hammer and cold chisel; and good specimens, if they cannot be obtained otherwise, must be loosened at the base with a putty-knife or spatula.

Besides these instruments I carry with me a clasp-knife to cut off the overhanging "sea-weeds" which intercept a view of the rocks beneath, and a little pad or canvas pillow stuffed with air and attached to a leather strap and buckle (which may be gartered round the right leg just above the calf to protect the bare knee against the cutting rock &c., as it is almost always necessary to bend down very low to see the under surface), a shrimp-net on a 6-feet pole, and weeding-iron on the like, to cut off and catch specimens which may be hanging from the under surface of the rocks beyond arm-reach, a 2-inch focus watchmaker's eye-glass, and two or three tin cans with covers (slung to strings attached to lateral ears, which they should each have for this purpose), to receive the selected specimens, in sea-water, as they are broken off from the parent rock respectively, whether at the time or at the examination subsequently made of the large pieces transported to the pool, as above stated, far above low-water mark. Add to this a basket and an old pair of boots to wade through the water, which will be often much above the knees, and thus protect the feet from being cut by the rocks and fragments of shells adhering to them.

Returning to the development of the sponge-ovule, I would observe that the oviparous sponges gathered on the 30th July have furnished me with all the observations needed for this communication, and therefore that those gathered on the 29th August were chiefly to corroborate the fact that about this time the marine siliceous sponges will be found available for the study.

Again, I have not been able to follow up the development of the ovule from its earliest appearance to that of the embryo and fully formed sponge in any *one* species only, from circumstances which will hereafter be mentioned; hence my illustrations of the early stages have been taken from one, and those of the later ones from another species.

Most of these illustrations, too, have been drawn to the same scale, viz. 1-12th to 1-1800th inch, in order that the relative size of the different objects at different periods of development may be the better realized. Thus, with the exception of fig. 1 in Plate XX., all the figures, from 2 to 12 inclusively, which are taken from *Halisarca lobularis*, are drawn to the scale mentioned; so are the remainder of the figures in this Plate (with the exception of the slight detail otherwise noticed), which have all been taken from *Grantia compressa*, in order, as before stated, that their sizes, relatively and respectively, may be compared with the figures of the embryos of *Halisarca lobularis* in the same, and of *Halichondria simulans* in the following Plate, in which the figures appear to be unusually large, but, to still preserve the scale for the purpose above mentioned, it was necessary that they should not be reduced; while in the third Plate, on account of the increasing size of the embryo after it begins to pass into the true sponge, and for other reasons which will be noticed hereafter, the figures, for convenience, *have been* reduced to the scale of 1-12th to 1-830th inch: thus it should be remembered that, for comparison with the foregoing, they should be more than double their present size.

By the illustrations in Plates XX. and XXI., having been drawn to the same scale, we are able to realize the relative sizes of the embryo of the gelatinous sponge, or *Halisarca lobularis*, of the calcareous sponge, *Grantia compressa*, and of the siliceous one, *Halichondria simulans*, respectively.

In studying the soft parts of a sponge, including the ovule, it is also essential to remember that they are *all* polymorphic, and, like *Amœba*, may at one moment appear in one form and at another in a different one. Thus the active spongozoon, which *in situ* may present a defined body, neck, head, and cilium, may, shortly after having been torn out from its natural position, and thus rendered passive, be changed into a simple, globular form. This form, in returning to partial activity, may again throw out pseudopodia from its sides (*Amœba*-like) and become reptant. The cilium, when the spongozoon is *in situ*, is used for bringing objects to the body; when the spongozoon is isolated it becomes an organ of locomotion, by which the body is propelled in front of it; from this state it may pass into a pseudopodial, prehensile form, and finally be retracted altogether; while the ovum, from its first appearance until after it has attained a considerable size, is always provided with a sarcodal envelope which, *Amœba*-like, gives it (up to a certain stage of development) a locomotive power. The student, therefore, must not be surprised, by-and-by, to find the embryo, after this manner, losing at once the cilia of its surface-layer of cells (the ectoderm), and the latter becoming a homogeneous-looking polymorphic or *Amœba*-like lamina of sarcode.

When the ovule for the first time becomes recognizable in *Halisarca lobularis* it does not exceed the 1-3000th inch in diameter, and then appears to be confined to the tissue of the sponge among the ampullaceous sacs (Pl. XX. fig. 3, *a*). Its envelope, however, already possesses the power of polymorphism and locomotion, as may be seen when it is scratched out from the parent upon a slide.

Subsequently, in *Grantia compressa*, it may be seen to be hanging, pear-shaped, upon the surface of the excretory canals, where it remains for a certain time locomotive, until, after further development, it becomes permanently fixed and the locomotive envelope seems to pass into a capsule. In this condition, too, I have described and figured it in *Tethya zetlandica* ('Annals,' 1872, vol. ix. p. 426, pl. xxii. fig. 14).

Although by necessity spread *throughout* the walls of the purse-like forms of calcareous sponges (ex. gr. *Grantia compressa*), it is nevertheless developed in *Halisarca lobularis* and *Halichondria simulans* (with which again in form the sessile spreading species of calcareous sponges, ex. gr. *Leuconia nivea* &c., are identical) close to the rock on which the sponge may be growing, where it becomes heaped up into masses, which present the ova in all stages of colour and development, from the first degree of duplicative division of the yelk to the fully developed embryo, whose colour seems generally to accord with, and be more intense than, that of the parent sponge, although in *Halichondria simulans* it is opaque white; while the upper part of the sponge becomes atrophied into a mere capsular layer (especially in *Halisarca lobularis*), and the vents appear to be in direct communication with the branches of the excretory canal-system, now expanded into common coverings for the heaps of ova respectively, which thus enables the embryos, when fully formed, to make their exit without difficulty. The position, in point of aggregation, of the ova in these sponges corresponds with that of most species of *Spongilla*; still, in some species of the latter, as well as in some of the marine siliceous sponges, they appear to be diffused throughout the mass—perhaps after all, however, being most plentiful about the base or oldest-formed portions of the sponge. While, therefore, in many instances, if the piece of rock on which the oviparous sponge, in this stage, may be growing is not broken off with it, the upper portion alone may be taken, and thus the ova escape observation. At the same time, almost all the specimens of *Halisarca lobularis* which I obtained on the 29th August, having been reduced to mere surface-shells, in which the red-violet colour of the spongozoa was unusually intensified, and from which the whole of the ova, having passed into the locomotive ciliated embryos, had escaped, and had thus left them hollow at the base, indicated that this date is too late for finding *Halisarca lobularis* in that oviparous condition which is requisite for following the development of the ovum.

To obtain the *ova* for examination it is absolutely necessary to tear the mass to pieces, and either examine them *in situ*, or seek for those which may have fallen out entire; while a few of the ciliated embryos that are far advanced may also thus be forcibly eliminated.

But, to obtain the embryos in a fully matured state, either in *Halisarca lobularis*, *Halichondria simulans*, or *Grantia compressa*, it is best to place the oviparous specimens of these sponges respectively in this stage of ovi-development in sea-water uninjured, and let the embryos escape by themselves naturally. This can be done by breaking off a portion of the rock on which the two former sponges may be growing, while with *Grantia compressa* it is only necessary to cut off the branch of *Ptilota* to which it may be attached.

Having thus got out a sufficient number of embryos for immediate examination and the study of their subsequent development, we have only to transfer them, by means of a pipette, to any convenient place for this purpose. In doing this, the end of the pipette, whose aperture should be large enough to admit the embryo, must be put into the water close to it, while the finger is pressed tightly upon the opposite end; then, when the finger is withdrawn, the embryos will, by the capillary attraction of the water, pass up into the mouth of the tube, and, by subsequently gravitating towards the lower part, when the pipette is held upright, may thus be transferred to a slide for examination or to a vessel for holding them without any further force. They will live for several days in pure sea-water, changed now and then for a fresh supply; and their whole development into the perfect sponge may thus be easily followed; but, as this process is not stationary, the embryo itself can only be expected to be in its perfect condition at the moment it issues from the parent sponge, and must then be examined for this purpose, as it changes somewhat every hour afterwards.

It has been above stated that to give the whole of the development of the ovule, from its first appearance to the fully developed sponge, I have had to study it in *two* species; that is, that, owing to the transparency of the ovules in the non-spiculous sponge *Halisarca lobularis*, the segmentation of the yelk is much better seen here *in situ* than in *Halichondria simulans*, where the ovum is opaque; while, as regards the embryonal form and subsequently developed sponge, not only its larger size, but the presence of spicules in the embryo, and their final arrangement into the skeleton-structure of *Halichondria simulans*, render the embryo of this sponge much more eligible for this part of the development than that of *Halisarca lobularis*, in which there are no such aids.

We shall first, then, commence with the development of the ovule from its earliest appearance to the ultimate segmentation of the yelk in *Halisarca lobularis*, and then follow the development of the embryo into the perfect sponge in *Halichondria simulans*, comparing the latter afterwards with the development of the embryo of *Grantia compressa* into *its* perfected form, thus supplying, to a certain extent, that detail of which the late Prof. R. E. Grant discovered the salient points forty-seven years since ('Edinb. Phil. Journ.'), and taught them to me, his friend and pupil, in his lectures thirty-three years ago at University College.

It should be here mentioned that this subject is not *entirely* new to me, as I have already described and figured the ovum, in *Tethya cranium* and *T. zetlandica* respectively, from preserved specimens, in which it had probably advanced to very nearly the full period of embryonal development ('Annals,' 1872, vol. ix. p. 409, pl. xxii.).

Entering, now, upon the chief subject of this communication, it will, for convenience, be desirable to divide the development of the living sponge-ovule into four periods, viz.:—

1. That from its earliest appearance to the commencement of the duplicative division of the yelk.

2. That from the first duplicative division of the yelk to its ultimate duplicative subdivision.

3. That from the formation of the embryo to its fixation or stationary position.

4. That from the stationary position of the embryo to the development of the perfect sponge.

First and Second Periods.

As the first and second periods are taken from *Halisarca lobularis*, it is desirable to premise a description of the oviparous state of this sponge in both these periods; but as the former has already been done ('Annals,' 1874, vol. xiii. p. 433), there is no occasion for a repetition of it here, though it is necessary to add to my former description that the surface of *Halisarca lobularis* is covered with vibratile cilia (Pl. XX. fig. 1, *ee*), which is not the case with that of *Halisarca Dujardinii*.

In the second period, however, it differs in that the ova are greatly enlarged, and, instead of being diffused throughout the substance of the sponge, are gathered, as before stated, into heaps at its base (fig. 1, *bb*), where they rest upon the bare rock on which the sponge has grown (fig. 1, *cc*).

Here, too, although they are respectively encapsuled, the heaps or groups are each as respectively enclosed in a common membrane (fig. 1, *g*), which appears to be a dilated form of the excretory canals opening at the vent (fig. 1, *f*), by which the embryo (fig. 1, *i*) when it leaves the capsule (fig. 1, *k*) can find an easy exit. Further, the parent sponge has become reduced to a mere shell or layer (fig. 1, *aa*), in which however, the spongozoa of the ampullaceous sacs, as before stated, seem to present a more intensified red or pink-violet colour than ever (fig. 1, *d*), and the vents show themselves to be provided with a sphinctral diaphragm of sarcode (fig. 1, *f*) somewhat contracted, as if to regulate the egress of the embryos.

First Period.

That from the earliest appearance of the ovum to the commencement of the duplicative division of the yelk.

If we take a portion of *Halisarca lobularis*, at any time of the year probably (if it is not too young), and tear it to pieces in sea-water (for sea-water must always be used for these purposes to keep the parts alive), we may observe, with ¼-inch compound power, ova from the 1-3000th to the 1-1000th inch in diameter (fig. 3, *a*, *b*) ; in the smallest of which (*a*) the yelk and nucleus are already visible, although the nucleolus and germinal vesicle can hardly be distinguished with this power until they have become a little larger (*b*), while all are respectively enveloped in a layer of sarcode, which, being polymorphic, carries the ovum about with it as an *Amœba* does its nucleus (fig. 3, *c*).

At this time the ova appear to be imbedded in the substance of the *Halisarca*, while the smallest size only exceeds by one quarter the diameter of the spongozoon (fig. 2, *a*). How they escape from this position, except by their reptant power, I do not know.

But if we take a horizontal slice off the inner surface of a *Grantia compressa*, and place it on a slide in a little sea-water with a glass cover over it, we may see the ova, when they are not more than 1-1700th inch in diameter, attached to the surface of the excretory canals, where they not only hang pendent in a pyriform shape, but sometimes leave this position and become reptant (perhaps the human ovum creeps down the Fallopian tubes in this way ?) ; so that we may fairly infer from this that, in *Halisarca lobularis*, they follow the same course—that is, pass into and become attached to the excretory canals. This stage, as already noticed, I have described and figured in *Tethya zetlandica* (*op. et loc. cit.*). After a while, however (that is, in the latter position, viz. the excretory canals), they increase to the size of 1-180th of an inch in diameter (10-1800ths), when the polymorphic envelope appears to become transformed into a capsular covering, which, at one point, adheres to the parent sponge, and thus placenta-like probably continues to nourish the ovum.

Second Period.

That from the first duplicative division of the yelk to its ultimate duplicative subdivision.

In the second period I have above stated that the ova are found to be much enlarged and congregated upon the rock at the base of the sponge, where they appear in all stages of development, from the first duplicative division of the yelk (figs. 4 to 10 inclusively) to the perfect embryo (figs. 11 & 12); hence it is only necessary to place a portion of the sponge bearing the ova in this condition under ¼-inch compound power, and seek for the successive duplicative subdivisions of the yelk, from the first to that which appears to be the last duplicative subdivision (fig. 1, *hhh*), since, although it is easy enough to determine these divisions from the first to the third degree inclusively, in which the yelk becomes divided into *eight* cells (fig. 6), the other degrees (figs. 7–10) must be judged of by the comparative size of the cells; and thus all the rest of the illustrations of this duplicative subdivision have been selected in this way, from the fourth (fig. 7) to the seventh (fig. 10) inclusively.

If, on the other hand, the ovum, while undergoing this duplicative subdivision, be isolated and compressed under a glass cover and $\frac{1}{4}$-inch compound power, a nucleus and nucleolus will be observed, as figured in the illustration of the first degree of duplicative division, viz. that in which the yelk is divided into *two* cells only (fig. 4, *dd*). But, as this compression &c. cannot be carried into effect when the ova are viewed *in situ* and *en masse* (as in fig. 1), the nucleus cannot be then seen for want of sufficient light, and therefore is not introduced into the other figures, although it must be assumed that, whenever a cell undergoes division, the nucleus does so also, and that if these cells, however much subdivided, could be brought under sufficient compression, and thus rendered sufficiently transparent, each would be found to contain a nucleus.

There is also another feature which characterizes this period, viz. that the ovum is *without colour*, while very soon after the ultimate duplicative subdivision of the yelk is reached, and the yelk begins to be elongated into the form of the embryo (figs. 11 & 12), the latter presents the same kind of red-violet colour as the spongozoa.

Striking, however, as this distinction is, the ciliated ectoderm, which becomes such a prominent feature of the embryo, is developed over the yelk while the ovum is still colourless and apparently has not begun to elongate itself into the embryonic form.

It is thus interesting to find that the yelk in the lowest undergoes the same kind of segmentation as in the highest animals, as if in all this preliminary process were absolutely necessary to the further evolution of the new being. Nor is it a little interesting to me to find also that my drawings of it *to-day* in the sponge correspond exactly with those which I made in 1837 from the ova of the freshwater newt, when as a student, aided by my dear friend Dr. Sharpey, I followed throughout the development of this reptile in ova obtained from a pool in the "Regent's Park."

There are yet two illustrations of the embryo of *Halisarca lobularis* to be described; but as it is our object to proceed direct from the last segmentation of the ovum in this sponge to the formation of the embryo in *Halichondria simulans* (that is, from the second to the third period of ovular development), we shall have to return to these hereafter.

Third and Fourth Periods.

As the third and fourth periods of the development of the sponge-ovum will be followed out in *Halichondria simulans*, Johnst., it might be as well to briefly premise the following description of this sponge:—

Halichondria simulans.

General form digital, cylindrical, solid, branched; procumbent, adhering here and there to the rock on which it lies; or flat, sessile, and spreading. Colour greyish brown or yellowish. Vents sparse, scattered, large. Internal structure composed of sarcode and the usual ampullaceous sacs (Pl. XXI. fig. 23), hung upon a reticulated, anastomosing, horny, fibrous skeleton, imbedding *one* form of spicule *only*. Spicule acerate, smooth, curved, rather abruptly pointed, often somewhat bent in the middle; average largest size 8 by 1-1800th inch in its greatest diameters (fig. 24). Size of entire specimens variable.

Hab. Marine.

Loc. Plentifully on the under and overhanging surfaces of rocks.

This sponge, which is very common on this coast, has been named by Dr. Bowerbank "*Isodictya simulans*" in one part (vol. ii. p. 308) and "*Chalina simulans*" in another (vol. i. p. 101), also (*ib.* p. 277) "*Isodictya simulans.*" At this confusion I do not wonder, since in my proposed division of the sponges generally this sponge would come among the Chalinidæ or third division, and *Isodictya* in the fifth division or RaynerIæ; while the distinction between *Chalina* and *Isodictya* is only one of degree, viz. the almost total absence of supporting *horny* fibre in the latter.

The ova of *Halichondria simulans* in the second period appear in the form of opaque *white* grains in the centre or oldest portion of the cylindrical forms, and at the base close to the rock in the spreading forms, just as in *Halisarca lobularis.*

By what stages the spheroidal ovum passes into the elongated embryonal form, I do not know; but the ciliated ectoderm as well as the spicules are already developed in the former, as before stated, in *Halisarca lobularis*, and shown in the illustration of the ovum of *Esperia ægagropila*, var. (Pl. XXI. fig. 25)—that is, probably immediately after the subdivision of the yelk has been completed.

Third Period.

That from the formation of the embryo to its fixation or stationary position.

As, however, the spheroidal ovum elongates, the posterior end becomes marked by the development of a brownish-yellow coloured mass of cells, which subsequently take on a globular form (Pl. XXI. fig. 22, *a*), or are arranged round the base in a circle (fig. 21, *f*), contrasting strongly with the *opaque white* colour of the embryo. The latter, now becoming fully matured, bursts through its capsule and swims into the water. At this time it is very large, as may be seen by the illustrations (figs. 21 & 22), compared with the embryo of *Halisarca lobularis* (Pl. XX. figs. 11 & 12), and especially that of *Grantia compressa* (figs. 13 & 15), which, for this purpose, are all drawn, as before stated, to the same scale. In shape it is cylindrical (fig. 21), conical at one end and round truncate at the other, measuring 1-30th inch long by 1-90th inch wide. At the anterior end is a papillary projection (fig. 21, *e*, & fig. 22, *f*), and at the posterior one the brown cells mentioned (fig. 21, *f*, and fig. 22, *a*); while all the rest of the surface is covered by the ciliated ectoderm or layer of minute monociliated cells (fig. 21, *d*).

(In the illustrations this ciliated layer has only been generally represented, by dots all over the body, in the embryo of *Halisarca lobularis* [Pl. XX. fig. 11], but for convenience has been omitted in the rest, or rather reduced in representation to the dotted line round the margins of the other figures respectively.)

Besides the cilia of the surface there is a line of very large ones of a distinct kind, and five times as long as those of the ectodermal layer, which encircles the base and forms a mutual boundary to the brown-coloured mass of cells on one side and the ectodermal ciliated surface on the other (fig. 21, *g*, and fig. 22, *e*).

The cells of the brown-coloured mass, on the other hand, which are much larger than those of the ectodermal layer, present themselves, as before stated, in a globular form (fig. 22, *a*) or in a simple circle round the base (fig. 21, *f*).

In progression the embryo swims with the papillary or pointed end foremost, and rotates upon its long axis from left to right, as indicated by the arrows respectively on the illustration (fig. 21, *h*, *i*), and as if the cilia on its surface were arranged spirally.

When the embryo is crushed it is found to be filled with sarcode charged with cells and granules of different sizes, together with the spicules of the species (figs. 21 & 22, *b*), the latter very delicate, and the larger cells filled with smaller ones (figs. 21 & 22, *c*), as if they were the commencement of the ampullaceous sacs, which we shall by-and-by find so numerous in the perfected sponge.

While the cells of the coloured mass (fig. 22, *a*) at the posterior extremity are of the same size throughout, and independent of the colouring-matter of the sarcode which surrounds them, the cells of the ectoderm of the body and of the coloured mass are, respectively, about ½, 3, and 2-6000ths inch in diameter.

It has already been stated that the ciliated ectoderm and the spicules make their appearance while yet the ovum retains its spheroidal shape; and it might be added that all the forms of the spicules belonging to the species make their appearance about the same time, whereby, even at this early stage of development, the species may thus be determined to which the ovule belonged, as will be seen by the illustration of an ovum of *Esperia œgagropila*, Cart., var., on the rocks here (fig. 25), wherein the skeleton-spicule (*b*) and the three forms of flesh-spicules, viz. anchorate (*c*), bihamate (*d*), and tricurvate (*e*), are all present. The tricurvate here is very long and straight, as may be seen by fig. 26, which represents one in its mother cell from the parent sponge, thus chiefly constituting the "variety."

It should be particularly remembered, however, that the spicules in the embryo are not confusedly dispersed throughout the body-substance, but are, in their natural position, *confined* to the *posterior* part, close to the root-cells, where the long ones are grouped parallel to each other and to the longitudinal diameter of the embryo, with their large ends posterior and their small or pointed ones anterior (Plate XXII. fig. 28, *e*). It is only when the embryo is carelessly crushed on the slide, for microscopical examination with a high power, that they appear to be *generally* dispersed throughout the body.

Having placed twenty embryos of *Halichondria simulans*, such as that above described, in a glass vessel (finger-glass) two thirds filled with fresh sea-water, I observed that while they often attached themselves, by the posterior end, to the bottom of the vessel, some became shorter in length, with a corresponding widening (Plate XXI. fig. 22); and thinking that they wanted to become fixed, while remembering the habit of this sponge to grow on the under surface of the rocks, I dropt into the bottom of the vessel a small, dark, subangular pebble of quartzite, about ½ inch in diameter, obtained from the *centre* of a piece of red-sandstone conglomerate in order that it might be free from impurities, and shortly afterwards observed that one of the embryos had become fixed to the under part of an overhanging portion of this pebble, which in no position ever risked the crushing of the embryo by resting upon the glass. This pebble with attached embryo (Plate XXII. fig. 28, *d*) was immediately transferred to another finger-glass of the same kind, and the remainder of the embryos left to themselves. As it might be confusing to state any more about the latter here, I defer *this* for a future opportunity.

Fourth Period.

That from the stationary position of the embryo to the development of the perfect sponge.

Having now a fixed embryo, I placed it under an inch compound power, and observed that it had become attached by the *posterior* end (Pl. XXII. fig. 28), which still presented the brown-yellow-coloured mass of cells that distinguishes this point (*c*), and was further marked by the circlet of long cilia that, undergoing retraction, still played languidly round the base (*e*), while the whole of the ectodermal cilia had become retracted (*a*), leaving the embryo with a white, smooth, even surface, and the papillary projection still on the summit (*b*).

(Here it should be observed that, whenever the embryo was subjected to examination, the pebble was turned over or to one side, so that both the upper and lateral surfaces of the embryo might be seen and measured respectively, while at the same time this was always done *under* water, out of which the embryo was *never* taken until after it had become developed into the perfect sponge. Finding, too, that I was obliged to use another microscope for this, in order to get the vessel in between the table and the object-glass, and that this necessitated my using another micrometer, whose divisions were equal to the 1-830th of an inch, instead of the one I had been using, whose divisions were equal to only 1-1800th of an inch, while if the measurements had been reduced to the latter and the objects drawn to this scale, in accordance with those on the previous plates, they would be inconveniently large for this one, I determined to draw them on the scale first mentioned, allowing 1-12th to 1-830th of an inch, by which it will be seen, and should be remembered, that they are on a scale which makes them a little less than half the size they would be if drawn upon the scale first used, viz. 1-12th to 1-1800th of an inch.)

The fourth period occupied just a week, viz. from the 4th to the 10th of August inclusively; and the embryo was examined in the way above mentioned twice a day, viz. morning and evening, during this time.

On the 4th and 5th it altered very little in appearance from what has been above stated, beyond becoming a little wider and shorter (Pl. XXII. fig. 28).

On the morning of the 6th the now unciliated ectodermal layer seemed to have descended from the body of the embryo, and, in a homogeneous and transparent form, to have spread out on each side in a denticulated manner, much like that of an *Amœba* (fig. 29, *a a*), by which the body, now erect and conical (fig. 29, *b*), but still opaque, white, and smooth, became more firmly fixed to the pebble. The papillary eminence also appeared to have somewhat subsided into a depression or excavation (fig. 29, *c*).

But in the evening of the 6th the embryo, still continuing the same in other respects, had lost its smooth even surface, and now presented a monticular or polygonal one of a more or less globular form (fig. 30, *a*), with the vent more pronounced (fig. 30, *b*). It was evident, from what I had seen before in the development of the young *Spongilla* from the seed-like body to which I have alluded, that the spicules in the interior of the embryo of *Halichondria simulans* were being arranged into a skeleton-structure in which their ends, in bundles, forced outwards the dermal membrane of the embryo, and thus gave rise to the irregular monticular surface mentioned.

During the 7th and 8th days, the projection of the spicules, still *under* or *within* the ectodermal membrane, became more pronounced, the body more expanded at the base, and the homogeneous transparent ectodermal expansion more or less withdrawn (fig. 31).

On the morning of the 9th the ectodermal membrane had become separated from or raised into a kind of film all over the free surface of the embryo (fig. 32, *c c*), by the projection of bundles of spicules from the opaque white body of the latter (fig. 32, *b b*), thus causing the opaque portion (fig. 32, *a a*) to be surrounded throughout above the base by a hollow interval (fig. 32, *d d*), bounded by the ectodermal layer on one side and the opaque body of the young sponge, *now fully formed*, on the other. To the ectodermal layer and this cavity I had, in my paper "On the Ultimate Structure of *Spongilla*," given the names respectively of "investing membrane" and "its cavity" ('Annals,' 1857, vol. xx. p. 24, pl. i. fig. 1). The latter forms the "intermarginal cavities" of Dr. Bowerbank—strangely, figured from the same sponge as our embryo came from, viz. *Halichondria simulans*, under the names (as before stated) of *Chalina simulans* in one part, and *Isodictya simulans* in another (B. S. *l. c.* plate xix. fig. 299).

At this point of development the spicules, now in a naked form, project a little beyond the "investing membrane" or ectodermal layer (fig. 32, *c c*); and could I have brought a $\frac{1}{4}$-inch compound power to bear upon it in this development, as in the development of *Spongilla* from the seed-like body, in a watch-glass, I might have observed the pores, and finally the composition of the investing membrane or ectodermal layer itself, which again, strangely, in *Spongilla* I have described as consisting of flat cells like *Amœbæ*, forming a "foliated arrangement not unlike a compressed layer of multifidous leaves ever moving and changing their shapes" (*l.c.* p. 25, pl. i. fig. 7). I say "strangely," because this membrane, in the embryo of *Halichondria simulans*, must also be composed of polymorphic cells, although with their cilia now retracted.

Of the same nature, composition, and functions as the investing membrane in *Spongilla* we may, then, fairly assume that in the embryonal sponge of *Halichondria simulans* to be; and I would recommend any one who wishes to make himself confident of this to consult my paper and illustrations on the ultimate structure of *Spongilla* (*op. et loc. cit.*).

The single vent, now the end of the branched excretory canal-system, may be observed to traverse the cavity of the investing membrane and to open on the surface (fig. 33, *a*).

Thus the passing of the embryo into the perfected sponge may be considered to have become complete.

On the 11th of August I sought, as before, eagerly for a current of particles issuing from the vent, but could observe none; and fancying that the development had become stationary (in fact, that a slight retraction all round the young sponge indicated approaching dissolution), I determined not to try to feed it with indigo in order that I might see if it already contained fully-formed spongozoa and ampullaceous sacs, but at once tore it to pieces on a slide in sea-water for this purpose, well knowing that a little delay in doing this would expose the whole structure to the ruinous influence of hosts of devouring animalcules.

This was done, and then the structure of the parent sponge was observed to have become fully developed (fig. 34). The skeleton structure was found to consist of a reticulated horny investment supporting bundles of the acerate spicule of the species (fig. 34, *a a*), some of which, as before mentioned, projected beyond the confines of the opaque or parenchymatous portion of the sponge so as to support the investing membrane (fig. 34, *e e*), while the whole of the inner part of the skeleton was imbedded in sarcode charged with minute cells and granules (fig. 34, *b b*), among which could be perfectly distinguished the monociliated spongozoa, isolated (probably from the force used in tearing the specimen to pieces for examination), and in the aggregated globular forms of the ampullaceous sacs of the species (fig. 36, *c*, *d*, *g*), both of which corresponded in appearance and measurement with the like in the parent sponge, which had been previously examined, measured, and sketched for this reference, and may be found among the illustrations (Pl. XXI. fig. 23).

Thus the sponge-ovule, from its first appearance to its final development into the perfect sponge, had been completely traced; and thus its apparently chaotic mass had passed into definite forms by that mysterious power whose manifestations only we can comprehend.

[To be continued.]

XL.—*On the Invertebrate Marine Fauna and Fishes of St. Andrews.* By W. C. M'Intosh.

[Continued from p. 274.]

Class CRUSTACEA.

Order Podophthalmata.

The stalk-eyed Crustacea of St. Andrews are chiefly northern in type; and though the species are not numerous, many are very plentifully represented. The most important forms here, as elsewhere, are the edible crab and the lobster. Both are caught in considerable numbers along the border of the rocks by means of the ordinary crab-pots, which are generally baited with fragments of grey gurnards and other fishes of little value. The most successful ground is off the East Rocks, though a very large lobster in the Museum of the University was procured to the north of the West Rocks. Some of the fishermen have an idea that if a lobster enters a trap first, none of the edible crabs will venture beside it, whereas a lobster will invade the crab-pot though a dozen of the former are already there. Constant attacks seem to have diminished the numbers of both species, and especially of the lobster. I have never seen any of the latter between tide-marks; but young edible crabs are common under ledges and stones, and even in the sand at low water, their presence in